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MANUSCRIPTS should be submitted to the Editor, Charles M. Burrill, Radio Corporation of America, David Sarnoff Research Center, Princeton, New Jersey.

ABOUT THIS ISSUE

This issue begins with a scholarly review of major researches in a field that is currently one of the most talked about in research management, namely, creativity. This review was presented at the Lake Placid meeting of the Industrial Research Institute last October. It is by Herbert A. Shepard of the Esso Standard Oil Company, who also contributed a paper on alternate managerial and technical ladders in research which appeared in our Autumn 1958 Issue. Dr. Shepard is particularly well qualified to prepare this review of creativity because of his training as a sociologist and his experience in a large corporation where research is effectively done and where it is understood and appreciated. Dr. Shepard attended McMaster University and the University of Toronto, and in 1950 obtained his Ph.D. in industrial economics at Massachusetts Institute of Technology.

As in the Autumn Issue, we include in this issue one paper from each of two sessions at the Lake Placid meeting of the Institute; these sessions were on the subjects, "Professional Unionism," and "The Effective Use of Personnel Audits."

In the last issue our paper on unionism discussed a case where it appears that the professional employees may vote the union out; in this issue we present a discussion of a case where a professional union and research management appear to have reached equilibrium. This paper is about the experience of the Standard Oil Company (Indiana) at Whiting, Indiana, and is by M. T. Carpenter, Administrative Director, Research and Development Department. Mr. Carpenter graduated from the University of Kentucky in 1930 and thereupon was employed as a chemical engineer by Indiana Standard. He has remained with that company ever since, and since 1938 has held various administrative positions. In 1954 he was president of the Scientific Manpower Commission.

Our paper in this issue on personnel audits describes procedures followed and evaluates results obtained at the General Electric Research Laboratory at Schenectady, New York. The authors are Glenn W. Giddings, formerly Personnel Manager at the General Electric Research Laboratory and now Consultant, Educational Relations, the General Electric Company, and Lowell W. Steele, who is currently Salary Administrator at the General Electric Research Laboratory. Our readers may wish to compare this account of General Electric experience with the experience of the Standard Oil Company of California as discussed by Dr. Arthur L. Lyman in our Autumn Issue. In addition to his industrial research and administrative experience with General Electric, Dr. Giddings was formerly a physics professor and Assistant Dean of Men at De Pauw University. He received his Ph.D. in physics from the University of Wisconsin in 1930. Dr. Steele came to the General Electric Research Laboratory six years ago, having received his doctorate in industrial economics under Dr. Herbert A. Shepard at Massachusetts Institute of Technology.

For our readers interested in small companies we are happy to present a paper by Maurice Holland, one of the early pioneers of industrial research who, as Director of the Division of Engineering and Industrial Research of the National Research Council for 18 years and as consultant in private practice for another 18 years, has helped to bring the benefits of research to many companies, both large and small. Maury Holland has retired to live in our southernmost state, but none of his multitude of friends would expect him to be inactive. Thus nothing was more natural than that we should find him presenting a lecture-seminar at the Advanced Management Conference at the University of Hawaii last summer on the subject of getting research and development started in small firms. The present paper is based upon the material that he presented on that occasion. It is most fitting that we should publish this paper by the only Honorary Fellow of the Industrial Research Institute.

RESEARCH MANAGEMENT

In the last paper of this issue, General Leslie E. Simon, Vice President and Director, Research and Development, of the Carborundum Company asserts that research must become a well integrated part of a single continuum of applied science in the corporation and not strive to exist as a separate entity. The research honeymoon is over, he says. This paper was presented at Niagara Falls, New York, in March 1959 before a joint meeting of the Canadian Institute of Mining and Metallurgy and the American Institute of Mining, Metallurgical, and Petroleum Engineers. General Simon became Director of Research and Development for the Carborundum Company in 1956 upon his retirement from the U.S. Army as Major General after a distinguished career in the direction of ordnance research and development. He graduated from West Point in 1924 and received the B.S. and M.E. degrees from Massachusetts Institute of Technology in 1929.

MAJOR RESEARCHES IN CREATIVITY*

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What investigations are properly called creativity research? Evidently, studies which concern themselves explicitly with creativity, ingenuity, originality, independent thought, inventiveness, innovation, genius, the talented, the gifted, eminence, scientific performance, problem-solving, and brainstorming should all be assessed; but what of studies that concern themselves with brainwashing rather than brainstorming, with conformity, dependency, and resistance to change? In some ways the latter areas may seem to bear a relationship to creativity studies analogous to the relationship between basic and applied research—which is usually seen as one of remoteness from or irrelevance to the immediate problem. Although that may be the usual relationship between basic and applied research, occasionally one encounters conditions under which the longest way round is the shortest way home. One of Gestalt psychology's major contributions to understanding the creative process lay in early investigations of the "umweg" or "detour" principle[1] which might be generalized as follows: the more you want something, the less likely you are to be able to think of more than one approach to it. Umweg phenomena can

* Presented at the Fall Meeting of the Industrial Research Institute at Lake Placid, New York, October 12–14, 1959.

† Since this paper was submitted, Dr. Shepard has accepted a position as Professor of Behavioral Science, Case Institute of Technology, Cleveland, Ohio.

readily be demonstrated by putting grains of corn on one side of a fence six feet long, and a chicken on the other side, opposite the corn. The chicken tries frantically to get through the fence to the corn instead of going round the end. It is only when the chicken becomes so distraught that it begins to pace the floor that it accidentally finds the end of the fence.

Although it is not permissible to generalize from the uncreativity of chickens to the value of applied research or research in creativity, it does seem that some creativity studies have fallen into the same trap as the chicken. This thought has been more graciously expressed by the poet Hoffenstein,[2] as "squint-eyed gazing at the stolid sun, and getting spots for his enquiring mood." In my review of creativity studies I was victim to this same squint-eyed gazing. It was not until I began pacing the floor that I began to suspect there might be an end to the fence, or at least to these metaphors. My discovery—or, in Gestalt terms, my "Aha" experience—contained about as much basic originality as the chicken's. It was simply that a good way to advance scientific knowledge is the experimental method, a method that has been used all too little in creativity research. And in the latter part of this paper some experiments are cited which give promising leads in the creativity area, although most of them were primarily concerned with some other phenomenon.

These introductory comments are not intended to discount the creativity studies that have been made. There has been much progress in creativity research, progress along several dimensions. Some old hypotheses have received relatively unambiguous confirmation or denial, and some new hypotheses and concepts have emerged. While the field is still dominated by an individualistic orientation whereby creativity is regarded as an innate property of the individual, there have been some pioneering studies in which it is viewed as an interactional process between individal and environment or as a social process in which the individual participates.

Much attention has been directed to the question of creativity criteria. The importance of adequate and consistent criteria may be conveyed by the following example. Northway and Rooks[3] studied children building toy houses out of blocks, and measured deviations from a model house demonstrated by the experimenters. They found that children who were unpopular with other children copied the model house; popular children made houses different from the model. The experimenters concluded that creativity arises out of being socially integrated with others, rather than being a compensation for lack of popularity as some observers have thought. But is creativity simply making something unlike the model? Sheer difference does not seem an adequate definition of creativity. At first glance, it might appear that we could at least agree that copying is *not* creative. But it depends on the definition of copying. The introduction of equilibrium theory into the social sciences was a clear case of copying since the concept was borrowed from the physical sciences. Yet this concept in some of the social sciences had an effect of exactly the kind described by Ghiselin[4] as the highest level of creativity, namely, it ". . . alter[ed] the universe of meaning by introducing into it some new element of meaning or some new order of significance." On the other hand, not all copying from one field into another has this effect. Reasoning by analogy is notoriously perilous. For example, it is doubtful whether Murray's[5] description of the creative process by analogy to metabolic processes and especially sexual fertilization is likely to have an impact on creativity research comparable with that of equilibrium theory in the social sciences.

Such considerations bring into focus a problem that has haunted creativity research. Are the criteria for creativity to be found in the product, or in the process that gives rise to the product? Most researchers are interested in both, but in practice their results have been profoundly affected by the primacy they give to one, as well as the means by which they identify elements in the process or evaluate the products.

Emphasis on some aspect of the product as the criterion facilitates historical-demographic research and an oversimplified interpretation of the creative process. Lehman's[6] studies illustrate this point. Using for his criterion the importance of a work as judged by experts in the field, he found the familiar relationships between age and achievement in various occupations. Although he listed some sixteen factors which might give rise to this relationship, the interpretation was widely made that creativity decreases with age for physiological causes. More careful study of the processes that probably lie behind Lehman's curves, especially by Brozek,[7] Dennis,[8,9] and Meltzer and Pelz,[10] correct this impression. In a study of contemporary physiologists, Pelz found that when motivation and opportunity remain high, production of significant work continues into middle age—in fact, Pelz's curves place the peak of creative productivity under these conditions in the early fifties.

Similar oversimplifications characterize the early work on genius and eminence in science as represented by Galton,[11,12] Cattell,[13] and Cox.[14] They found that heredity is a primary determinant of eminence in scientists and in other men. On the basis of more modern studies heredity cannot be completely discounted, but there is much evidence that it is a minor rather than a major factor. Thus Roe's[15] study of eminent scientists shows such determinants as intellectual atmosphere of the home, childhood interests, and position in the birth order to be of major importance. Knapp[16] places great emphasis on the culture and social environment of the small, midwestern college of sectarian origins as a background determinant of scientific achievement. He and Goodrich[17] note that sectarian colleges produce the greatest number of scientists in the years immediately following secularization. Lehman and Witty[18] found that 75% of those listed in *American Men in Science* in 1931 indicated no religious affiliation. Many observers, *e.g.*, Merton,[19] have noted the almost complete absence of Roman Catholics from the rosters of eminent scientists.

Studies of eminent men are misleading in another sense, since the criterion of eminence is probably not a reliable index of creativity. Thus, such students as Cox[14] and Galton[12] enquire into the personal characteristics of eminent men, and find that they possess such qualities as great ambition, desire to excel all others, great persistence, and great energy. Roe,[15] using a criterion of scientific eminence, found similar factors in a number of cases. Studies which have focussed on the creative process itself, such as those of Guilford and his associates,[20] do not show these factors to be consistently associated with creativity, however. Guilford finds that those showing originality are "more tolerant of ambiguity, and more interested in esthetic expression . . . less active physically, and [feel] less need for order, for discipline and for cultural conformity." Knapp[16] finds his creative subjects repress aggressive impulses. Based on his longitudinal studies of gifted children, Terman[21] emphasizes that eminence is a poor measure of creative capacity, a product of chance combinations of personal merit and environmental factors.

Turning now to studies in which the criteria of creativity are sought in the creative process, we find that the earlier researches had a high degree of subjectivity about them, a tradition which continues to the present day in numerous speculative theoretical writings and in psychoanalytic and related psychological interpretations. Poincare's[22] autobiographical essay on mathematical creation is the classical description of the creative process. Gestalt psychologists have made much of the "Eureka" phenomenon, and have related it to other elements in Gestalt theory, like the need for closure. Perhaps the most instructive work in Gestalt psychology is Wertheimer's[23] collection of cases and essays on productive thinking, in which he emphasizes the importance of gaining insight into the "structure" of a problem. Although little experimental work in creativity has emerged out of the Gestalt tradition, Bavelas informally reports a study in which problems bearing a superficial resemblance to "standard" engineering problems were

given to engineering students at all levels between freshman and senior years. The problems were not in fact standard ones, but required a fresh insight into their own structure for solution. The freshman performed better than the seniors.

In the psychoanalytic and related psychological writings, the age-old argument about the relationship between creativity and emotional disturbance remains unresolved, but there is a strong modern tendency to view creativity and psychological health not only as compatible, but mutually supportive. Some clinicians, like Rogers,[24] see creativity as motivated by the healthiest of life forces, man's tendency to grow, to mature, to realize his potentialities, and see psychological ill-health as the enemy of creativity. Maslow,[25] paying closer attention to the evidence, hedges by distinguishing between special talent creativeness, in which the person, by virtue of special talent, may be creative although emotionally disturbed, and self-actualizing creativeness which is correlated with and dependent upon psychological good health. Kubie[26] comes out strongly for psychological health, says that no one need fear that getting well will cause an atrophy of his creative desires; on the contrary, he believes that neurosis always interferes with creativity. But Bellak[27] sees the creative person and the disturbed person as sharing certain unusual qualities, the creative person differing from the disturbed in his ability to pull himself together. Roe[15] notes that the responses to projective tests made by many of her subjects would be interpreted clinically as maladjusted. And Greenacre[28] observes that the psychic organization of the creative individual is more similar to that of the perverse individual than to that of the neurotic.

The apparent inconsistency of these positions is probably a consequence of several factors: different psychodynamic theories and definitions of psychological health; the use of different criteria for creativity; a tendency in some cases to identify the individual's creative capacity with his creative drive; and a good deal of variability among writers in the extent to which they attempt to

analyze the complex interrelations among such factors as an individual's social and personal adjustment, his desire to be creative, his success or failure in being creative, and the social response to his creativity or lack of creativity.

Another tradition in which the emphasis is placed upon the creative process as criterion is represented by the early work of Wallas,[29] who identified four stages in the creative process: preparation, incubation, illumination, and verification. While some others (notably Patrick[30]) have provided data in support of Wallas' stages, there is more evidence for Vinacke's[31] view that it is necessary to conceive of creative thinking in terms of dynamic, interplaying activities, rather than as more or less discrete stages.

In general, modern students have shown little interest in trying to identify stages in the creative process, though a number have given attention to the classification of creative processes and products according to level or type. For example, I. A. Taylor[32] distinguishes five levels of creativity: purely expressive, as in the spontaneous drawings of children; productive, as when the individual gains mastery over some portion of the environment; inventive, in the sense of finding new uses for old parts; innovative, which changes the basic foundations of a theory; and emergentive, or the ability to absorb common experiences and produce something quite different, as in the case of Einstein.

The bulk of modern psychological research on the creative process has sought to identify mental or emotional factors or traits associated with or forming essential elements of the creative process. The instrumental or applied aspect of such research has consisted of tests for the presence or absence of certain mental or emotional factors, and tests for prediction of creative performance.

Guilford[20,33] and his associates have identified a number of aptitude traits bearing on creativity, and have developed tests to measure them. In Guilford's view, the principal traits are ability to see problems, fluency of thinking, flexibility of thinking, originality, redefinition, and elaboration. There is close correspond-

ence between this list and the list of traits identified by Lowenfeld[34] and his associates: sensitivity, fluency, flexibility, originality, skill at redefinition, ability to abstract, ability to synthesize, and coherence of organization. It is noteworthy that both lists are of "mental" or "intellectual" traits, rather than of "motivational," "emotional," or "temperamental" traits. The question of motivation for creative mental activity such as originality is raised by Guilford, but ambiguously answered.

Other groups have paid more attention to temperamental and motivational factors associated with creativity. Stein[35] and his associates and Barron[36] find that intelligence bears little relation to the tendency to make original responses to situations. In comparing highly intelligent persons who are low in originality with highly original persons who are low in intelligence, Barron finds that the latter describe themselves with adjectives which suggest that they do not control their impulses well, whereas the former describe themselves as unusually well controlled. Cattell and Drevdahl,[37] in comparing successful scientists with the general population, find them more intelligent, more dominant, more adventuresome; they show more stability, have less standard moral goals, are more radical and self-sufficient. Barron[38] finds that creative people are more observant, value accurate observation, value telling themselves the truth, see things as others do but also as others do not; they are independent in their thinking, are constitutionally vigorous, have much sex drive, live complex lives, have strong egos, are more destructive and more constructive, crazier and saner than other people. Stein[39] finds that his more creative subjects are less authoritarian, more dynamic, more integrative, more autonomous than his less creative subjects.

That Guilford[20] could find no temperamental traits consistently associated with creative aptitudes while Barron, Stein, and Cattell and Drevdahl independently find various such sets of temperament traits (not, however, completely consistent with one another) does not invalidate the work of any or all of them. Dif-

ferences in constructs and in methods of measurement contribute to the confusion, but differences in criteria may well be the most important factor.

Guilford and Barron appear to rely to a considerable extent on responses to certain tests for a criterion. Stein uses judgments by qualified people of the subject's creativeness. Cattell and Drevdahl study "successful" scientists. The contamination which may be introduced by treating different criteria as equivalent is suggested by Barron's finding that creative people are fond of complexity, an observation that is not substantiated by other investigators. Again, the unpredictability introduced by using "success" or "eminence" as a criterion is illustrated in Roe's work. She found temperament variations associated with success in the various scientific fields.[15] Her observation about eminent biologists,[40] for example, was that they are "unaggressive, but stubborn; conventional; with a distaste for the imaginary and an unwillingness to go beyond the facts." These characteristics are badly out of tune with most of the evidence regarding factors making for creativity, but are not logically incompatible with the requirements for eminence in a field whose history has emphasized taxonomical skill and meticulous observation of detail.

Tests for the prediction of creative performance have been developed at several centers. Stein developed several promising tests on psychological, biographical, and environmental factors in creativity. In collaboration with Stein and Science Research Associates, some member companies of the Industrial Research Institute will subject these tests to extensive evaluation and validation procedures. Harris and Semberg[41] have developed a test at AC Spark Plug which successfully differentiates between persons judged on other grounds to me "more" or "less" creative. Saunders[42] of Educational Testing Service reports tests which differentiate successful from unsuccessful research workers. Psychological Corporation has a Test of Productive Thinking, and American Institute for Research has tests for selecting research personnel.

As progress is made in test development, the search for objective criteria continues. Harmon[43] attempted to discover the criteria judges rely on in their judgments of creativity. In the situation he studied, the judges appeared to rely heavily on the subjects' number of publications. Stein[44] studied the problem-solving approaches, operations, and steps used by scientists who had been rated by highly qualified judges and found striking differences between the procedures used by the "more" and "less" creative. The need for a more comprehensive and unified program of test and criterion evaluation has been recognized by C. W. Taylor at the University of Utah, and he has a major study under way with the aim of bringing more order into this complex segment of creativity research.

In most of the studies cited up to this point, the hand of individualistic psychology has been uppermost: the search has been for the creative individual, the aim to predict individual performance, the interest in the internal processes—intellectual and emotional—of the creative person. The criterion itself, whether located in the product or in the process, has been individualistic. But many of the investigators in the course of their studies became intrigued by the influence of past or present environment on the performance of their subjects. Thus Roe was sufficiently impressed by environmental influences to title her book "The Making of a Scientist," and she stresses the importance of early home and school influences. Similarly, as Stein's work progressed, he came to place more and more importance on the life-histories and social environments of his subjects. He found[45] that the more creative were more distant from their parents, that their parents' attitudes to them were more inconsistent, that they indulged in more solitary and fewer group activities. Stein[46] also places emphasis on the present work environments of his subjects, on the culture and social structure of research departments. For example, he found that working scientists see little correlation between creativity and organizational success, whereas persons at

higher managerial levels believe that creativity and success are highly correlated. Again, D. W. Taylor[47] found that in his sample, the more creative research workers were differentiated from the less creative in terms of numerous social characteristics.

Taking a second step away from individualistic psychology, a few investigators have tended to view the creative process as a social process, the creative product as a social product. Thus a body of scientific knowledge is seen as emerging from the social interaction of scientists, communicating directly or reading each other's work, jointly developing a language and operations for exploring and explaining some aspect of the universe. Each scientist possesses not only a heritage of scientific method and theory in relation to which his own creative contribution must be evaluated, but also a heritage of culture and a position in a social structure. The latter influence the scientist's creative potential, and also have a creative potential of their own. Theoretical statements of this sociological view of the creative process have been made by a number of students, *e.g.*, Parsons,[48] Merton,[49] Barber,[50] and Shepard.[51] Empirical research stemming from this viewpoint has been of two kinds, macroscopic and microscopic. Typical of macroscopic research is Knapp's analysis of the creative potential of the small midwestern sectarian college,[16,17] and West's[52] attempt to identify cyclical variations in creativity in Western cultures over the past 2500 years. Microscopic research is represented in some studies by Shepard and Pelz. Shepard[53] found that industrial research groups rated lower on creativity had a more authoritarian atmosphere. Pelz[54] found that participative leadership in research groups was positively related to good scientific performance. Also, Pelz found that creative research workers spent more time with scientists from fields other than their own than did their less creative colleagues, and Shepard[55] found that research groups whose members had been together for a short time were rated as more creative than groups whose members had been together longer.

Nearly all of the investigators whose work has been cited, whether individualistic, social psychological, or sociological in their viewpoint, have made little use of experimentation. As a result, the principal products of creativity research which research managers can hope to make use of are tests for selection and prediction. About how to make less creative people more creative, creativity research has taught us very little indeed. Knowing the factors in the creative process is presumed to improve creative abilities, but the evidence for such a presumption is slim. The psychoanalysts may be of some help, as Kubie assures us. Parnes and Meadow[56] find that instruction in brainstorming techniques can improve the quality and quantity of ideas. And psychologists interested in gifted children have addressed themselves to the problem of developing native talent (Torrance,[57] Thistlethwaite[58]). On the whole, however, principles that a research director can use to guide his decisions as a manager and his actions with his staff are lacking.

Because social experimentation requires manipulation of the social and environmental conditions under which individuals and groups perform, an experimental approach to the creative process holds most promise as a source of principles and procedures useful to research managers. Although few experimental social scientists have addressed themselves directly to creativity, numerous experiments have at least an indirect bearing on the subject.

Crutchfield[59] found differences in independence in individuals, and showed that some individuals under conditions strongly structured to produce conformity are still willing to express a divergent opinion. Similarly, Torrance[60] found that some individuals show more willingness to oppose others and disagree when the situation requires it. Eber[61] found that authoritarian persons operate well under authoritarian leadership and poorly under permissive leadership, while nonauthoritarian persons operate equally well under both styles. These findings suggest that individuals differ in the amount of structure required for them to operate well.

Gibb[62] found that groups were more creative under conditions of low threat than under conditions of high threat. Horwitz[63] found that the problem-solving performance of subjects in a classroom situation fell off when the amount of influence they had over classroom procedures was arbitrarily reduced by the instructor. Horwitz concluded that almost any power relationship from authoritarian to completely permissive can be used as long as the expectations of the subjects are fulfilled by it. That the style of leadership should be appropriate to the task is suggested by Adams,[64] who shows that air force bomber crews operate best under moderately equalitarian leadership. From both the experimental evidence and organizational studies,[53,54] it can be inferred that leadership style is an important determinant of creative output.

Blake[65] found that in three-person groups a subject is unable to perform well intellectually when opposed by the other two members, and also when supported by the other two members. Quality of intellectual production is highest in a support-conflict situation, where one other member opposes, and the third supports. Horwitz[63] shows that the capacity for problem-solving can be almost completely destroyed when individuals are given powerful evidence that others unanimously disagree with them in every respect.

Rose and Felton[66] and Nash and Wolfe[67] have experimented with small groups with constant and changing membership. Nash and Wolfe found that subjects moving to a new group are less inventive than regular members, while subjects returning to an old group after having been with a new one are more inventive than regular members.

These experiments are illustrative of a direction for research which may well be fruitful both of knowledge about the conditions under which creativity occurs and of methods for creating those conditions.

The relevancy of such experiments to our understanding of creativity recalls the "umweg" theme stated at the outset of this

paper. Most of the experiments were undertaken for some purpose other than the discovery of facts about creativity. Nash and Wolfe were interested in studying laboratory analogs of open and closed societies. Horwitz was interested in studying various distributions of social power and the effects of power reduction. In this sense, the long way round does give some promise of being the short way home, and an old belief in the value of "pure" research receives some new support.

Perhaps the same "umweg" principle should be used as a guide in managing for creativity. Too great a premium placed on creativity in the research organization may amount to a condition resembling threat rather than a condition under which people can be creative. Besides, overemphasis on creativity may suggest that there is an easy way out for the research worker who is repelled by the laboriousness of scientific work. D. W. Taylor[47] found that the productivity of research workers was less predictable than their creativity. However, there is at least some evidence that many a productive research worker has the capacity for being creative if the rules of the game—his self-imposed rules, or the pressures under which he is required to work—permit him to go off on tangents when he finds that he cannot quite reach the corn through the fence. Too often the only rule is that he should scratch more ardently.

The author wishes to acknowledge his indebtedness to Professor Morris I. Stein of the University of Chicago and Professor Robert R. Blake of the University of Texas for extensive annotated bibliographies on creativity, which greatly facilitated the writing of this paper.

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UNIONIZATION OF PROFESSIONAL PERSONNEL: A CASE HISTORY*

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Our experience in living with a union of professional employees at the Whiting, Indiana refinery and research laboratory of the Standard Oil Company (Indiana), spanning a period of fifteen years, has taught valuable lessons which we believe can be of help to others in formulating policies. We have had to learn how to cope with the problems, but we have also learned to keep some problems from arising. In this, good communication is the most important factor.

Professional employees are really not much different from other employees. They look at those who belong to unions, and some ask themselves, "Why don't we have a union? Maybe it would get us more recognition. Maybe we could even get more money." The law says they can organize. If they do, the law says the company must bargain with them.

Many professional people see a paradox in this situation. The professional man wants individual recognition; unions say somebody should speak for the employees as a group. Management sometimes thinks that unionized professional employees want to eat their cake and have it too, that they want the prestige but not

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the responsibilities of professional status; the employees may think management fails to understand their problems and objectives. These conflicts are the sources of the problems that arise when professional employees organize a union.

At Whiting the union is called the Research and Engineering Professional Employees Association. It includes research scientists as well as refinery engineers. Membership is restricted to fully qualified professional employees. The union is not affiliated with any outside group. I shall first describe the circumstances existing when the group organized and then tell something of the problems we have had since that time.

Prior to the passage of the Wagner Act in 1935, all nonsupervisory employees at Whiting, including the professional people, could express their desires and grievances through a Joint General Committee which was composed in part of representatives elected by the nonsupervisory employees and in part of representatives appointed by the management. This type of organization was pioneered by our company. It functioned at most company locations for many years. However, the Wagner Act made such an organization illegal for bargaining purposes. In order to provide a channel for bargaining under the new law, the nonsupervisory employees organized the Standard Oil Employees Association which became the sole bargaining agent for all nonsupervisory employees at the Whiting refinery.

It appears that most professional employees at that time were not concerned with union matters. In any event, no objection was raised to their inclusion in the same bargaining group with nonprofessional employees.

The union had little interest in the then small group of professional employees. As time went by, some of the professional people realized, however, that they might run into difficulties if they continued to be represented by a union in which they were a small minority. Union troubles at the Shell Development Company in California were receiving publicity in the technical jour-

nals. At Whiting, both management and professional staff were frustrated by uncertainties caused by salary-stabilization regulations inaugurated during World War II. The rate of pay for work in excess of 40 hours per week was an important question. Representation by a union whose primary concern was with production workers was not likely to be especially helpful to the professional people; under some conditions it would be potentially detrimental to their interests.

Because of circumstances existing at that time, the best way to separate from a predominantly nonprofessional union was to form a new group, composed entirely of professional employees, which the National Labor Relations Board would recognize as an "appropriate unit." This was done and, in 1944, the Research and Engineering Professional Employees Association was certified as the bargaining agent for all professional, nonsupervisory employees at Whiting. The 1947 amendments to the National Labor Relations Act and the recent decision of the U.S. Supreme Court in the Westinghouse case make it clear that professionals may not be included in a bargaining group with nonprofessionals against the wishes of the professional group. If these actions had been on the books when the professional employees at Whiting wanted to get out of the refinery union, they might not have wished to organize a professional union.

I feel sure that the officers and representatives of the professional union at Whiting have usually been motivated by a sincere desire to be of help to the company as well as to improve the economic and professional standing of their members. On many occasions this has led to frustrations on the part of union representatives. Particularly when they first take office, union officers frequently have the idea that their union is different from other unions. They would like to work with the company on a "one big happy family" basis. They forget that theirs is a labor union which is subject to the same rules as other labor unions.

This is probably the key point in the relations between a

professional union and a company. Even if professional employees were inclined to strike to achieve their demands, which most of them are not, their economic power cannot be as effective through strike action as it is in the case of production workers. Professional employees therefore seek a closer working relationship with management. This is a fine ideal. Management must bear in mind, however, that any advantage gained for the professional staff through bargaining may be seized upon by other unions as an excuse for demanding equivalent benefits, even though the benefits might have to be expressed in some different way.

Now I shall tell about some of the actions taken by the professional union at Whiting. I suggest that you keep in mind a basic point of conflict. The desire of many professional people to consider themselves part of management is not consistent with the desire of other professional people to enforce their demands through collective bargaining. It is difficult to sit on both sides of the bargaining table.

Since 1944 the professional union at Whiting has bargained with the company on most of the usual union issues and has added a few issues of its own. Each year the company and the union bargain about a general wage increase. Frequently in the past, general salary increases granted professional employees have paralleled the increases given the other union-represented employees at Whiting.

Some of the early bargaining with the union dealt with the job-classification system. Parallel lines of advancement are provided for administrative or line positions, on the one hand, and purely technical positions involving no supervisory responsibility on the other. The union, in its booklet entitled "Introduction to the Research and Engineering Professional Employees Association," claims credit for the establishment of this system. The fact is that the system was in existence before there was a union. In this case management had failed to communicate. Consequently, the union could claim credit for something it did not do.

In fairness, it should be pointed out that the union representatives did not know anything about the classification system. They may have thought it was established as a result of bargaining. In any event, it was through the union's efforts that the professional staff learned about it. Other instances could be cited where management failed to communicate with the professional employees. They may have been driven by these communication failures to think they needed an organization to speak for them.

Another bargaining subject during the early years was that of starting salaries and automatic salary increases for new B.S. and M.S. employees. Here again, the professional employees learned first from the union about an existing company policy. The union did not accomplish anything for the employees except to let them know what company policy was. Fifteen years later it seems clear that it would have been much better to communicate with the staff about things like this.

Other bargaining subjects during the 1940's included the rate of pay for the extended work week during the war and the increase in base pay rates upon return to the 40-hour week. In 1948, an agreement was reached to increase the patent-assignment fee from $10 to $50.

During 1957, one of the bargaining subjects was a request from the union for information about salary history. The union wanted details concerning recent salaries of each individual it represented, without identification of the individual. The company agreed to provide this information. The company also provided, on its own initiative, a chart showing the salary structure of the entire department, including all supervisors. The chart showed the 25th, 50th, and 75th percentile lines of salaries as of January 1, 1958. This was done again as of January 1, 1959. We plan to do this each year. This is an example of communication with the professional staff.

From this chart a professional employee can see where he stands relative to his fellow workers, including supervisors all

the way to the top. He can also see how much money he may be able to make in the future, depending upon his standing in the department. Professional people like to know that they are not regarded as a statistic. They recognize the need for salary control for the entire department, but they want to be assured that individual performance will be recognized. This must be demonstrated by actions as well as words.

Other items discussed in 1957 included the condition of a parking lot, the results of an attitude survey conducted by an outside organization, a request from the union for larger participation by their members in national technical-society meetings, and the amount of help in the first-aid room.

In 1958, in addition to bargaining for general salary increases, the matters discussed included the average price paid for company stock under the company savings plan, the expense of operating the company's extended medical expense plan, attendance at technical society meetings, sales of newspapers in the lobby, car passes for admittance to the refinery, salary increases above the maximum of the range for a job, and a complaint that professional employees sometimes had to provide their own messenger service.

Early in 1958 the company and the unions representing nonprofessional employees at Whiting agreed to a 2% general increase. A survey of rates paid in the area showed that this was justified. However, the professional staff had received unusually large individual merit increases in 1956 and 1957. Also, starting salaries for professional employees had been going up rapidly for several years. The company therefore felt that no general increase was justified for the professional staff in 1958. The collective bargaining agreement provided for individual merit increases for the professional employees as determined by the company. Accordingly, the company decided that the money to be used for individual merit increases should be increased by 2% of payroll. The union was informed that this was being done. The

money would be awarded on the basis of individual merit; there would be no general increase. The professional union thereupon charged the company with an unfair labor practice, claiming that the company was not bargaining in good faith and that the company's action constituted discrimination against employees represented by the professional union. The charge was dismissed by the Chicago Regional Office of the NLRB, and, when the union appealed the dismissal, the NLRB General Counsel in Washington also ruled that the charge had no merit.

The company was anxious to continue in 1959 the 1958 practice of having all salary treatment on an individual performance basis. This policy had been in effect for supervisors before 1958. Wage and salary negotiations were opened with the three unions at Whiting early in 1959. Agreement was reached for a general increase of 5% for the refinery workers, including office employees. The company proposed to the professional employees' union that a performance-increase pool of at least 5% be established for employees represented by them. The union officers and the negotiating committee understood that the 5% addition to the pool was a minimum and that the company would add money to take care of individual situations, including promotions to higher ranking nonsupervisory positions.

The negotiating committee of the union objected. Under the proposal, a small percentage of their membership whose work was marginal in quality would have received no increase. The union board of directors voted 4 to 3 to accept the proposal. The membership, however, rejected it, 233 to 198. After further negotiations and after talks to the staff by the heads of the departments involved, another membership vote was taken and the proposal was again rejected. Agreement was finally reached and ratified by the membership that no union member should receive less than a 3% increase. Also it was agreed that all increases for 1959 should be given not later than July 1st. In the past, raises had been distributed throughout the year.

It is interesting to note that so many members of the professional staff were unwilling to make any settlement under which even a handful of people would get nothing. Apparently the feeling was that a professional man should receive an increase of at least the same order of magnitude as the production worker or he ought to be fired. Sometimes it is not easy, however, to dismiss a research man who has had many years of productive work but has lost his effectiveness.

The question might well be asked, "What are the disadvantages in bargaining with a group of professional people? Maybe it's a good thing to have a place for them to present their ideas and to blow off steam." In answer to this question, here are a few problems created for the company by the professional union.

(*1*) Probably the most serious obstacle which the professional union places in the way of the company is in recruiting. University department heads and professors sometimes are reluctant to recommend our company to their best men. These educators fear that a union impairs opportunity for individual advancement. There is no way to measure this recruiting disability, but we know that it is serious. Any publicity about the relations between the company and the professional union is news. It is quickly reported by the technical journals. The mere suggestion of trouble is considered in some circles to be a reflection on the company. It is also considered to be a reflection on the professional staff, particularly on the individuals known to be involved. The merits of the issue are frequently of no concern to outside professional people. They feel that squabbles between a company and a professional union have no place in accepted professional conduct. The recent unfair labor practice charge brought by the professional union at Whiting against the company is a good illustration. It was a newsworthy item. It brought no credit to the company or to the employees involved, even though the charge was declared unfounded by both the Chicago Regional Director of NLRB and the General Counsel in Washington.

(*2*) Another problem occurred in 1949 when the company decided to provide more liberal hospitalization and medical benefits. The professional employees at Whiting were prevented from receiving the more liberal benefits for more than a year because the professional union was not satisfied with all the details of the company proposal.

(*3*) A third problem arose when the general salary increase of 1957 was delayed for professional employees at Whiting for a month because the professional union was unwilling to accept the terms offered by the company. After a month's delay they finally settled for these same terms.

From this brief discussion I think it is apparent that unionization of professional employees does introduce problems for both the employees and management. They are not insolvable problems.

It is entirely possible to bargain with a union of professional employees and still treat the professional staff as professionals. If it is necessary to deal with a professional union, it should be remembered that no long-range good can be accomplished by taking any vindictive action against the union, if such action hurts the professional employees. They should be treated as professionals, even if this becomes difficult because of actions taken by overzealous union officers.

Management has the tools to determine the nature of its relations with its professional staff. Good communication is the key to good relations. Professional work in an industrial organization usually is, or at least can be, carried out in such a way as to make communication easy: meetings are usually held with different levels of management, frequently at regularly scheduled times, to discuss technical problems. Management should take advantage of these meetings to pass on to the professional staff items that might be of interest to them. These meetings can be a natural forum for an exchange of views on a wide variety of topics. However, this communication channel must be opened by

management and the professional employees must be made to feel that their views are welcome.

Most professional people tend to identify themselves with management unless they are frustrated by lack of communication. Professional men are trained to think in an organized manner and to be analytical. They will usually arrive at the same conclusion as management if they have the same information to work with. It would be impossible to give every professional man complete information on all subjects in which he might be interested. However, if he is expected to be sympathetic to the objectives of management, he should at least know about things that affect him directly. He should know where his salary stands relative to the general salary structure for the professional staff. He should know what his salary might be if he reaches different levels in the organization. It will do no good to tell him that his progress will be limited only by his ability and his performance. There should be no equivocation in telling him how his superiors evaluate his work.

Whenever possible, the professional man should be taken into management's confidence concerning the current status of the company and the prospects for the future. This must be done in bad times as well as good. Otherwise, the professional man will not believe what he hears.

Almost any member of management will agree with the basic policy that communication with the professional staff is a good idea. However, many people in management pay lip service to this idea and then fail to take advantage of opportunities to communicate. You cannot ignore your professional staff during good times and then expect their trust and support when a crisis develops.

If you want your professional people to act in a professional manner, you have to treat them as professionals. If they do not know what you are thinking, you cannot expect them to understand your objectives. Fifteen years of experience has taught us one thing: communication is not only a good word; it is a sound policy.

PERSONNEL AUDITS AND THEIR EFFECT UPON RESEARCH PRODUCTIVITY*

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In his recent book, *On War,* Raymond Aron, the French sociologist, emphasizes that in assessing the present situation it is essential to have what he calls "a sense of history." In assessing where the General Electric Research Laboratory stands today in the field of personnel administration, it is likewise essential to have a sense of history. Let us outline how we got where we are today.

Some eight or nine years ago, a profound metamorphosis began to take place in the General Electric Company. A very important part of the change was an entirely new approach to the compensation of personnel. A fairly highly developed system of man evaluation and maturity-curve compensation was given up in favor of a system of job evaluation and performance appraisal.

* Based upon a talk by Glenn W. Giddings at the Fall Meeting of the Industrial Research Institute, Lake Placid, New York, October 14, 1959.

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We must confess at the outset that those of us in the Research Laboratory who were concerned with administration of research personnel were well satisfied with our previous scheme of evaluation and compensation. We knew of none anywhere that we liked better, and we were reluctant to set forth upon new uncharted seas. But the winds of change were blowing, and we set sail. Our first tack involved retaining an expert consultant with an intriguing theory of compensation, and we went on for a year and a half before it became apparent that we were on the wrong course. The reasons were simple: the plan required an expert for its operation and administration, and it was something that was done *for* the research managers, not something they did themselves.

After this false start, we took a quite different tack. Recognizing that a workable system must have both the cooperation and the participation of research management, we enlisted the research managers in the effort from the beginning. The first thing that was done was to analyze the work of research. This is not easy to do. Just what is it that a research man does? What are the elements of research work? What distinguishes different levels of technical competence? Is it possible to describe the work of research in any manner other than by describing the work of particular individuals?

One of our research departments, the Metallurgy and Ceramics Research Department (particularly through the efforts of R. W. Schmitt, J. J. Becker, and R. C. Leech), developed a "wall-to-wall" chart listing all the elements of the "work" of research and all the degrees of difficulty and levels of technical competence that could be separately identified. They were able to identify seven different degrees or levels of research work that encompass the entire range from the work done by an inexperienced college graduate to that which can be done by an internationally known research scientist.

The seven identifiable levels of work form the basis of seven "generic" position descriptions or position guides for research

work. These seven position descriptions, expressed in words having generally accepted meanings, represent the most precise statements we have been able to devise for distinguishing any one level of research work from the six others. (A skilled manager with intimate knowledge of research work and workers can make finer distinctions than those in the descriptions. This is good, because the company's compensation plan involves at least twice as many compensation levels as the number of position descriptions we have been able to devise.) The seven generic position descriptions form the basis of our salary evaluation plan. They provide the principal tool and are the first step in implementing our plan for evaluation and compensation of research personnel.

The group of seven generic position guides is available to every member of the research staff. Each member of the research staff, through a conference with his own supervisor, knows the level in which he is placed. With rare exceptions, he agrees that his placement is proper. It is usually clear, as it was to Cassius, that

> "The fault, dear Brutus, is not in our stars
> But in ourselves, that we are underlings."

Let us make one final statement about our use of position guides. We consider them an important first step toward more effective personnel administration. The process of preparing them was at least as useful as the end product in aiding our managers to develop a common language for describing the work of research. Each guide, taken in the context of the entire series, seems to describe a meaningful kind of research work both to those who are familiar with the system and to those who are introduced to it for the first time. On the other hand, the guides are at present quite broad, and differences between levels are often based on rather subtle interpretations of terminology. Consequently, we expect and, in fact, want the system to change as we acquire additional experience. Already we can see some indications of further applications. One likely development is the use

of the generic position guide by members of the research staff as a basis for establishing broad objectives to guide their efforts for the coming year. These objectives are not narrowly defined nor are they rigidly adhered to, but they form the background against which the work of the year can be carried out and performance judged.

The generic position guides that we have been describing are only the framework, the bare bones of the salary administration plan. The appropriate generic guide is adapted to provide a position guide for the work of each individual research man, delineating his duties and responsibilities. This is a difficult point. In setting out specific objectives for the man, there is always the danger that he may be run on too tight a rein. This, happily, has not turned out to be a problem.

The real meat of the whole personnel administration plan lies in the performance appraisal—the personnel audit. The performance appraisal is designed with three principal purposes in mind. Its first function is to provide an adequate basis for salary administration, through appraising the man in terms of the specific objectives for which he understands he is to be held accountable. The performance appraisal is explicitly related to the determination of salary, but there is no precise mathematical relationship between the appraised standard of performance and salary action. Changes in salary are consistent with, but are not dictated by the performance appraisal. The second main function for the performance appraisal is to provide information for employee counseling. The third main function is to provide information for individual manpower development. While the performance appraisal does not, in itself, constitute a personnel development program, it does provide means for the systematic acquisition of information to be used in a long-range development program for the individual.

It has been our belief that a sound system of performance appraisal should satisfy a number of fairly specific conditions. We

have felt that inadequacies of an appraisal system are at least as likely to occur in the manner in which it is administered as in the forms used. Here are some of the criteria we have established for our appraisal system. The form used should be as simple and self-explanatory as possible, and it should be set up so as to require that the manager give thoughtful attention to the appraisal. The factors used in the appraisal should be as nearly as possible the same as those listed in the position guide, so as to lead the rater to believe that he is getting at the heart of the problem and that he is appraising the employee on factors that are truly relevant and upon which he has some informed judgment. The information produced by the rating system should be adequate for use in decision making by both the manager and the employee. It should help the employee to establish a realistic set of expectations concerning his status in the organization and his relationship with his supervisor. In addition, the form should lead the rater from the more concrete and objective factors to more general and subjective judgments. Thus, the rater first makes those judgments about which he is most certain, and this permits him to construct a sound frame of reference on which to establish his more general and less objective judgments concerning strengths, weaknesses, and development problems of the individual. It is necessary, of course, that the rater be provided with adequate assistance by way of instruction, training, and guidance. Also, procedures should be established for obtaining information and opinions from others whose work is influenced by the performance of a particular employee. The final criterion is that an appraisal system should be designed so that it is amenable to audit and to correction of deficiencies.

The particular form that we first devised with a view to attaining the objectives mentioned above (providing a basis for salary administration, for counseling, and for individual manpower development) is a four-page leaflet that comes as near as possible to being a blank sheet of paper. The first page provides

space for information about the rater and the employee, and for a summary of the rating. Also, there is space for specific suggestions for improving the employee's performance and for the rater's comments on the counseling interview. The rating itself occupies the remaining three pages. The second page, Part I of the actual rating, provides an outline for listing the objectives or responsibilities of the position. Sometimes this page is filled out initially in collaboration with the man to be rated. Giving the man an opportunity to participate in the development of his own rating form helps to insure that he is familiar with the functions for which he is held accountable and with the criteria which will be used in evaluating his performance. Space is provided on this same page for an after-the-fact appraisal of how well the employee has fulfilled his responsibilities.

Part II of the rating form, which occupies the last two pages, provides space for an analysis of the factors affecting the appraisal. There are three main headings: Knowledge and Skill, Activities Involved in Performing the Job, and Demonstrated Personal Characteristics. The first heading is further broken down into Technical or Specialized Knowledge, Analytical, Experimental, or Theoretical Skill, and Skill in Communication. The second heading, likewise, is broken down into Planning, Problem Solving and Originality, and Judgment and Decision Making. Space is provided in each instance for rating the performance of the employee as to whether it is Marginal, Acceptable, Satisfactory, or Outstanding.

There is one additional feature of the performance appraisal system that we must not overlook. Each manager is furnished with a separate sheet titled Individual Development Analysis which he may use as part of his own records as background information about the man. This is the first step in a program of individual personnel development. The form provides a basis for judging whether a man's long-range prospects are good in his present type of work and for putting into sharp focus his principal strong and

weak points. In short, the development analysis provides a background for counseling on a long-range basis. Because of the nature of the individual development form, it is commonly not shown to the employee.

The major features of our plan have been detailed above in order that we might discuss some pertinent questions as to our use of personnel audits in personnel administration. Our present system, comprising position guides, performance appraisal, and individual development analysis, provides the sharpest tool for personnel administration that we have ever used. It is so much superior to our previous system, with which, you will recall, we were quite well satisfied, that there really is no comparison. Our former system had two almost completely independent parts: a rating plan, primarily for use in counseling, that was based on personal characteristics (the rating was made by the manager and by two peers of the employee), and a salary administration plan that depended upon a merit ranking list (the ranking was made by the managers in conference). On the ranking list, each man was judged to be a little better than the man below him, a little worse than the man above. The lowliest member of the research staff was, in a very real sense, compared with Irving Langmuir. The rankings were relative and there was no standard that could be used in counseling. The plan did provide a very direct connection between ranking and dollars of salary, more direct than the present plan does, but at the same time it permitted less discretionary judgment in establishing salary.

To put it differently, our present plan permits appraising a man's performance in terms of standards that can reasonably be set by agreement between himself and his manager. As a motivating device, it is inherently much superior to our previous plan, under which a man never knew what to aim for except being another Langmuir. This, of course, was not bad, but so far we have had no one else who quite hit that mark. One's concept of success is an important consideration here. William James is

reputed to have said, "Success is measured by the ratio of accomplishment to capacity." This is a very interesting definition. The lowliest helper may be a very real success when working at his full capacity, and he may be made to feel so under our present plan. It is our conviction that motivating research men to be productive is one of the greatest problems facing industrial research laboratories today. We believe our present system of personnel administration, including personnel audits, is an excellent tool for motivating to productivity and for rewarding the research man commensurately with his accomplishments. We would not want anyone to think, however, that we regard it as a perfect instrument. As in the case of democracy, or even Christianity, present practice falls somewhat short of the ideal. We do think, however, that we can say, with Browning's Rabbi Ben Ezra,

> "What I aspired to be,
> And was not, comforts me."

We have tried to assess, in a preliminary way, how successful our plan of personnel audits has been. We know that in many instances it has been useful as a counseling device. Part of this may be inherent in the plan itself. Part is certainly due to the fact that the manager cannot hide behind group judgments. The appraisal process, as a result, looms higher on his own horizon. In cases in which the manager has not done a good job of appraisal and counseling, the situation for the employee is probably less satisfactory than under our previous plan. Our present plan, however, does turn the spotlight on the manager and has probably been a direct factor in correcting some undesirable situations. Men whose managers do not appraise adequately resent what they consider lack of attention to a vital matter. They feel they have a right to know where they stand.

We described in some detail the first form that we devised for performance appraisal. We have been delighted at the interest that our managers in the several research departments take in this

whole matter, as indicated by the fact that other appraisal forms are being devised which the managers feel are better adapted to their particular circumstances. The tendency seems to be toward a more nearly blank sheet of paper for the rating form than we had the courage to propose. The performance appraisal and the counseling interview are increasingly regarded as a very personal and individual matter between man and manager, a matter that should involve certain guides or check lists but that should not smack of too much formalism and structure.

Some of the most forward-looking managers are modifying their approach to appraisal and counseling so as to emphasize mutual examination of career goals for the employee, the first step toward individual manpower development. The man may be asked some questions that he has not given much thought to before, such as: "Where are you heading?" "What do you really want to be doing five or ten years from now?" "What are you doing now to help you get there?" It may seem surprising that men who are interested in long-term scientific research sometimes give little thought to their own long-term goals. Some even resent as an intrusion questions of the type mentioned. It is our firm belief, however, that this sort of planning together is much less threatening to the individual and much more likely to be productive in the long run than sitting in judgment upon the past performance of the individual.

The personnel audit has spurred certain managers to face up to unpleasant situations involving poor performance or inadequate use of talents. The counseling interview provides a convenient ritual that aids managers in facing up to unpleasant situations and in taking appropriate action. A number of transfers have been initiated as a result of the plan. In a number of instances, the appraisal system has been the means for recognizing that a man's best future is not in research work, but in development or in some other activity, either within the General Electric Company or without. As a consequence, the plan has helped to up-grade the

competence of our research staff and to eliminate areas of real or potential discontent between a manager and one of his men.

There is one more thing that is distinctly on the positive side that should be mentioned. Perhaps the greatest benefit of the plan in motivating to productivity is one that has not yet been fully recognized. The appraisal process furnishes a valuable tool for the manager in evaluating his group in relationship to the work to be done—the whole technical program of his section. The manager is made aware of weaknesses and strengths in his people, of their changes in competence, and of possible mismatches between the distribution of skills and interests in the group as compared with the projected technical program of the section. Productivity of the group may, over a period of time, be considerably enhanced by this awareness.

For the overall plan to be really successful, of course, requires that the managers understand that their own performance appraisal will be affected in a very direct way by their attention to the performance of their people. While it is not perfect, our plan does appear to have very real possibilities. One of our managers said recently: "I can state unequivocally that the performance appraisal plan for employees is a fine thing for managers!"

GETTING RESEARCH AND PRODUCT DEVELOPMENT STARTED IN SMALL FIRMS*

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Research and development as practiced in the major industrial nations of the world is a four-edged tool to develop new and improved products, cut production costs through process research, develop new fields of application for product or services, and develop alternate or substitute materials. While the gross national product in the U.S. has increased about 3% a year in the last 20 years, expenditures for research have increased 10% a year in the same period. According to leading economists, the three major factors affecting the future growth and economic development of the country are: (*1*) war or peace; (*2*) population growth and housing; (*3*) R & D in industry. With 4,300 laboratories spewing out new products and services to meet the rising demand of the

* This article is based on a lecture-seminar before the Sixth Advanced Management Conference at the University of Hawaii on July 27, 1959. Because of the growing importance of research in the rapidly developing Pacific area, a few facts regarding the setting of this lecture-seminar may be of interest. The Advanced Management Conference is staffed with four professors from the Harvard University Graduate School of Business Administration, two of whom are rotated each year. The Director of the Conference, Professor Bart Harloe, also teaches engineering and economics as a member of the faculty of the University of Hawaii. The class members are drawn from the Pacific area countries, and are executives chosen by their companies to attend

1960 consumer market, the influence of R & D touches every sector of life in the nation. R & D is the new symbol in classic economic forecasting.

Although we may be spending 10 billion a year (2% of the national income) on R & D, that amount is not enough if the leading industrial nation in the world is to maintain its supremacy in this Space-Atomic Age. Less than 2% of our 250,000 manufacturing companies have "research insurance" against obsolescence of plant, product, process, and tools. We need 10,000 laboratories in the next ten years!

Research and Development is just as important to the small company as to the large one. However, it does present special problems for the small company, particularly in getting a program started. Let me illustrate by drawing a few "case histories" from our file of experience. I have selected the cases of three companies that I assisted in getting one-man research departments started.

Case Number One

The Hudson Pulp & Paper Co., a small, family-owned, diversified company with plants in Maine and Florida, was considered by executives in the industry as very good in the management areas of merchandising and efficient, low-cost production, but, according to a Vice President in charge of sales, "The three brothers who are the owners and managers know nothing about research. It's a problem of education. I have tried it for some time, but with no success; maybe an outside consultant is the answer."

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the six weeks' course. This year's class was limited to 60 members; there were 19 from Hawaii, 9 from the U.S. mainland; 9 from the U.S. armed services, and 14 from Australia. The average age was 44. Of these, 29 represented management (administrative); 11 management (technical); 6 management (finance); 4 management (sales); one each management (personnel) and education. A further breakdown by industries: finance, banking, and insurance, 8; government services, 13; agriculture, 4; mining, 3; oil, 6; chemical, 2; and miscellaneous, including zinc, paper, aircraft, food, electrical, iron and steel telephone and telegraph.

The first step was to organize a Research Policy and Planning Committee, with the President as chairman. The Committee met on a scheduled day each month, with representation from production, sales, finance, marketing, and engineering. The Committee was set up with these objectives: What are we going to do research on? Do we want to be twice as big in five years, in the same product fields we are now in, or do we want diversification more? Who is going to do the technical work? Shall we do R & D ourselves or farm it out? What facilities have we for doing technical work? How many technical men have we in the company in any capacity?

We had the personnel department make an inventory of all technical men, control laboratory people, and process engineers, and in our Southern plant we discovered Ray S. Hatch, formerly Director of Research for Weyerhaeuser Timber Company. Hatch who had retired to Florida became bored with no technical activity and took a part-time job with Hudson to do some experimental work on his own.

He had completed several experiments that yielded results which he thought looked most promising. His reports had been sent to the New York office, but no one knew where they were, Management had never seen them and did not know their contents. Copies were made of the report of an experiment which had showed real promise of an improved process for making tall oil, a product for which there was a ready market with prices rising. Also, he had applied for a patent on a process to substitute Manioca (made from maize) flour adhesive for animal glue which was used in large quantities on gummed paper tape.

After several Hatch reports were received by top management, he was brought to the New York office as Director of Research and Technical Advisor to Management. A small R & D staff was recruited from control laboratory and production engineering personnel. The R & D program got started with the sympathetic understanding of top management, which laid out

major guideposts for future technical effort. At the end of the first year, Hatch submitted his first annual report, which showed a return of $530,000 on an expenditure of about $150,000. His report was checked and audited by the accounting department.

In the second year, an additional laboratory was established at the plant in Maine to deal with mechanical problems of automatic machine napkin folding and packaging. Several new and improved products were brought out during the second year. The Research Policy and Planning Committee continuously reviewed the company's major product lines and made comparative tests against competitors' products. Hatch, who sat in on every management meeting, was made Vice President in charge of Research and Technical Advisor to the President during the second year.

Recommendations arising from this "case history" might include such items as: (1) Mesh management thinking with technological potential. (2) Select an experienced research executive with demonstrated performance. Give him the money and men to do the job and leave him alone. (3) Insist upon establishment of a Research Policy Committee with functions specified in writing, such as review progress monthly, establish project priorities, authorize appropriations, and approve annual budget; also supply R & D with "commercial intelligence reports" on product markets and trends.

Case Number Two

The Vermont Marble Company, a family-owned New England business, was limited to a single product—marble, although that product did have many variations in color and natural design. The best illustration of use of this product was Colorado Yule marble, which the company used in designing and making the Tomb of the Unknown Soldier at Arlington Cemetery. A literature search by the Engineering Societies Library of all the references to marble down through the ages indicated that the only word that was synonymous with marble was *cold*—"cold as marble"

—a familiar phrase which makes one think of cemeteries, marble slabs in morgues, and Grecian temples. One of the executives of the company summed up the primary problem: "Take marble out of the cemetery; bring it back into the home. We must find some way to warm it up!"

Some effort had been made to use improved technical methods for cutting the cost of sawing and polishing. A professor from a New England university was retained as a consultant. He made magnified photographs showing crystal size, orientation, and light transmission. The company decided to make 20 sample sheets, each about 20 in. long, 10 in. wide, and $^1/_2$ in. thick, of various kinds and colors of marble and these were sent to Dr. Matthew Luckiesh, Director of the Lighting Research Laboratory of the General Electric Company at Nela Park, Cleveland. When the scientists at Nela Park put high-watt electric lamps behind the sheets of marble, beautiful effects of natural color and design, some resembling seashore scenes, some mountainous landscapes, and an infinite variety of decorative effects were developed. The Nela Park staff arranged an exhibit for some of the leading industrial designers of the country who at once saw the great potential for illuminated marble panels in church altars, store fronts, motion-picture ticket booths and lobbies. The work at Nela Park was followed up by our "one-man research department," the university professor, who took samples to Mellon Institute to make further studies of crystal orientation and light transmission. Finally under the trade name LUMAR for the illuminated marble sawed so that the crystal orientation yielded maximum light transmission, a nation-wide advertising and sales promotion campaign opened up large-volume markets and a variety of new fields of application.

The next problem the company tackled was how to cut costs of sawing large blocks of marble. The traditional method was to use smooth-edged steel saw blades and sand which would gradually chew through the marble blocks. Sometimes weeks or even months were required to saw through large blocks. The company

enlisted the technical assistance of their supplier of steel saw bands and worked with the Norton Company on the development of improved abrasive material. After some months of tests supervised by a combined research laboratory staff of the steel and abrasive companies, a circular saw running at 13,000 rpm was developed which literally cut through blocks of marble as if they were butter. Research had performed two of its traditional functions: (1) it had developed new fields of product application; and (2) it had cut production costs, making it possible to lower price against the competition of other stone products and thereby to open new mass markets.

Case Number Three

The case of the National Blank Book Company, manufacturer of office supplies, loose-leaf notebooks, ledgers, and visual index files, was essentially the problem of a one-man research department in which the technical director was an inventive genius who had more than a hundred patents to his credit. Could his inventive technical talents be used as the core of a small organized R & D activity? A Research Policy and Planning Committee was formed to select technical projects which would wrap the research program around one inventive personality.

The owner-managers were technology-minded. They did not lock their lone-wolf inventor in a laboratory. Instead, they made him Director of Research, told him to classify the technical projects by fields of applied science and technology, authorized him to hire a small staff—a chemist, a metallurgist, a mechanical engineer, and a couple of designers. The Research Policy and Planning Committee set out to explore every resource, to screen ideas from customers, suppliers, university laboratories, commercial and testing groups, as well as from independent inventors. Setting aside 2% of company net worth for research activities each year, the company took the lead in new products in a tough, competitive field. One of the products cut costs so drastically that com-

petition was forced to take a license or a licking. A dramatic, new method of making loose-leaf book bindings and rings was developed. Formerly, the ring clasps had to be individually spot-welded in position by hand. With the new process, the back frame of parallel wires and clasps move through a machine where they are welded and formed in a continuous strip—in other words, made by the mile and cut off to size by the foot.

For more than two decades National Blank Book had bought hundreds of thousands of dollars worth of light green bond paper to be used in ledger and account books under the trade name of "Eye-Ease" paper. A market survey of user preferences and practices indicated that considerable improvement could be made with a "technical assist" from the large staff of the research laboratory of the principal paper supplier.

The research director, sales manager and production supervisor of National Blank Book visited with executives and technical staff of the paper company and presented specific improvements required by customers, such as better opacity, improved erasure-proof quality, improved color to ease eye strain in ledger, account, and stenographer note-books. The delegation from National indicated that they were visiting the research laboratories of several leading paper companies to see what new products were being offered from their technical laboratory shelves. "Our customers," they said, "have been reasonably satisfied with the high quality of our products, but our line next year must demonstrate the fact that the office-supply business has now joined the parade of technological progress." As a result, the company received some new and much improved raw material for their product from a technically alert supplier.

Research Resources for Hire

To assist small companies in fully utilizing research resources for hire, John Green, Director of the Office of Technical Services,

U.S. Department of Commerce, has compiled the following list.*

1. *University Research Centers:* The Engineering College Research Council publishes annually a directory of research in progress.
2. *Nonprofit Foundations and Research Institutes,* (of which there are nearly 100): Many have superb facilities and competence; the more notable are Armour, Battelle, Cornell Aeronautical, Franklin, Mellon, Midwest, Southern, Southwest, and Stanford.
3. *Commercial Laboratories* (of which there are several hundred): The earliest independent commercial laboratory was Arthur D. Little, Inc. of Cambridge, Massachusetts.
4. *Trade Associations:* Fifty leading trade associations engage in research for the benefit of their members.
5. *Professional and Technical Meetings.*
6. *Government Sources:* The monthly catalog of the Superintendent of Documents includes reports of scientific agencies of the U.S. Government. Direct contact with a government agency doing pertinent research is always informative and may be most effective.
7. *The National Research Council:* The Council publishes periodically a directory titled "Industrial Research Laboratories of the United States" which lists the executive officer in charge, the research executive, and the staff of the industrial research laboratories in the U.S.; the staff are classified into professional, technical and administrative groups.
8. *Periodicals:* There are at least 2,000 periodicals available in the U.S. covering science and technology.
9. *The U.S. Patent Office Gazette.*

* A more detailed listing will be found in M. Holland, *Management's Stake in Research,* Harper, New York, 1958, Appendix I. See also Charles N. Kimball, Research and Development Assistance for Small Business Outside of the Company," *Research Management,* 2, 13 (1959).

A small company embarking upon a program of research and development might want to use this checklist of technical-assistance resources and take advantage of them all. But as was stressed at the President's Conference on Research for the Benefit of Small Business held in Washington, "You can lead a horse to water, but you can't make him drink."

Summary

Some major steps in beginning a research and development program in a small firm are the following.

(1) Management should formulate a series of technical problems the solution of which will do most to expand and quickly develop the company.

(2) Hire a scientist or an engineer to start some experimental work and get technical assistance wherever it is available, either within or outside the company.

(3) Establish a Research Policy and Planning Committee to meet regularly with representatives from management, finance, sales, engineering, marketing, and R & D.

(4) Keep complete records in laboratory note books for patent purposes, record of progress, and financial control.

The biggest gamble in business is to do no research at all.

A CONTINUUM OF APPLIED SCIENCE IN THE CORPORATION*

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After spending over twenty years in research and development, I am ceasing to be a proponent of it as it is now widely practiced, particularly in industry. This is because the trends indicate to me that industrial research and development will cease to exist as a distinctively separate entity and that it will take its place in a continuum of applied science that is intimately interrelated to almost all the activities of the corporation. In the foreseeable future, such applied science will be organized as an integrated whole and will extend from truly basic research all the way through to engineering maintenance of the production line.

It is significant that in the transition period from the machine age to the age of science, research and development was often a part of the engineering department. As research and development grew, it sought its independence, largely because of frustrations due to lack of forward-looking administrators of the old engineering departments. Its separation was accompanied by jealousies and resentment which have scarcely died out today. (In this connection, see an interesting paper, "Problems of R & D Man-

* Presented at a joint meeting of the Canadian Institute of Mining and Metallurgy and the American Institute of Mining, Metallurgical, and Petroleum Engineers at Niagara Falls, New York, on March 25, 1959.

agement," by C. Wilson Randle, in the January-February 1959 issue of the *Harvard Business Review*). Now we are beginning to see that research and development and engineering should be put back together again in a single field of technology. The past need for their separation was not due to faultiness in their being together: it was due to lack of understanding of research and development in the then existing state of technology.

The conditions which engender engineering and scientific creativity have vastly improved. People now not only have time for the contemplative and reflective thought that is so necessary for research, the time is actually being urged upon them. There is not only communication, there is so much communication of research that a man cannot possibly read even a substantial portion of the publications in his own field. Today's grandchild of the inventor of yesteryear, unlike the eccentric inventor, is not only respectable but is avidly sought after, well paid, and showered with distinctions.

In a world in which change is the rule and nothing remains even approximately static for a significant length of time, this seemingly quite satisfactory stage, at least from the viewpoint of the scientist and engineer, is almost certain not to continue. If the scientist and engineer do not properly integrate their work into society as a whole, it is not unlikely that their state will worsen; reaction usually prevails in the long run. If they make the most advantageous use of the changes of which they are at least partly the creators, their status and the well being of mankind may advance to new heights. The impending change is one to enhance the individual's ability to keep up with the ever-increasing pace of science; and the change is economic in the sense of better utilization of the scientist and engineer.

A great many corporations have been seeking ways and means to evaluate the potential of research and development projects, and to determine over a period of time the value of research and development to the corporation. In short, one might say, the

honeymoon is over. We must face the facts. Research and development cannot rest on its laurels, cannot rely on its glamor, cannot exist as a precocious, peculiar, and pampered child; it must come under the scrutiny of factual analysis, live in a competitive society, and function at an optimum level in cooperation with the other segments of the corporation. In short, research and development must do what is good for the corporation. However, I believe we shall discover that what is good for the corporation is also good for research and development and for the scientist and engineer. In fact, surprising as it may seem, this can be an instance where that which is expedient is also moral.

Now let us ask what research and development does for the corporation. My answer is that research and development alone does almost nothing at all. Not only does it generally fail to contribute basic knowledge, but what it does do would be futile and useless without the subsequent work (even though it be crude and perhaps inept work) of production engineering, manufacturing, and marketing. Anything that is new comes from somebody's basic research; but in the corporation, research and development generally feeds on basic research to which it contributed little or nothing. If corporate research and development carries an idea through to a prototype and a successful engineering test stage, the earthy problems of making the product in an economic manner and of developing the market are usually passed on to the manufacturing branch and to the marketing branch. Research and development is often interested only mildly in improving the product at hand and may even resent trouble-shooting when there is customer dissatisfaction about the quality or quantity of a product. However, these are not really faults of research and development, they are primarily faults of management. Unsatisfactory relationships develop because scientists and engineers are not used to best advantage in their professional fields, but often are abused by being expected to do things outside of their fields and to do them well. What is more the pity is that beautiful principles of

proper organization have been highly developed by the business schools for almost every segment of business and industry except the field of applied science. The concept of feedback could do very much to guide research and development as it does advertising and other activities of the corporation, but it is almost neglected. All we have to do is appropriate some principles that have been worked out by business administration and we shall find much material for setting our house in order.

Not Research and Development But a Continuum of Applied Science

It is easy to see that what the corporation needs is not research and development per se but the whole continuum of applied science. What the corporation needs is an avenue to basic science (for which it should pay appropriately) and a proper integration of applied science or technology within its corporate structure. Research and development is a part of the spectrum of technology but by no means the whole of the spectrum. It is perhaps the brilliant red, but is preceded on the left by darker basic research and succeeded on the right by production-engineering orange, pilot-line yellow, manufacturing green, and market-development violet.

Superimposed upon the concept of the continuum of technology, the organization, the orientation, and the guidance of corporate technology must be derived from the objectives of the corporation. The very first step in the economic use of applied science is a matter of soul searching for these objectives on the part of management. Because it is beyond the scope of this paper, let us assume that a careful study has already been made of the business and financial aspects of the corporation, its plant and equipment, and, particularly, its skills, technology, and marketing organization, so that a "corporate map" can be drawn which will delineate the areas into which the corporation is free to expand,

without undue hazard, and signify the areas in which it should not attempt to participate. Without a knowledge of the aims and objectives of the corporation, it is no more possible to achieve a logical structure of technology than it is to achieve a logical marketing structure.

Some Principles for Scientific Organization in the Corporation

With the knowledge of the corporate map, it is possible to proportion, at least approximately, how much technical effort should be placed on new enterprises (diversification by developing new products for entry into new fields of enterprise) and how much technical effort should be devoted to improving and creating products along the established product lines. The former we may designate as aggressive research and development and the latter as defensive research and development. There are rather obvious reasons why the former should be independent of and relatively remote from manufacturing, and why the latter, which is really development only, should be proximate to manufacturing. Hard and fast principles for the economic use of applied science are difficult to lay down because some corporations are very highly specialized and because corporations differ enormously with respect to size.

Let us now address ourselves specifically to the moderate-sized decentralized corporation that is neither extremely specialized nor extremely diversified. Under these conditions it is generally logical that there should be a central research laboratory which contains what basic research the corporation supports, practically all of its engineering research for generating new technology (not actual designs of new products), and its development echelon for entirely new products. The corporate development activities for the enhancement of existing product lines should be in satellite laboratories under the line supervision of the heads of the respective production divisions. This organizational structure is rather

well known and is used by a substantial number of our leading corporations. However, these distinctions are merely a prelude to the treating of applied science as simply technology.

The bipartite organization consisting of a central laboratory for the generation of all new technology and for the development of new product lines and of decentralized technical branches within the manufacturing divisions for product and process innovations along existing product lines brings into sharp relief the wisdom of the continuous spectrum concept. A really new product can neither be gotten underway nor an old product improved without the creation of a new process and the design, specification, procurement, installation, and operation of the necessary machinery for implementing the process. In fact, one observes rather quickly that all of the higher functions of engineering, which are commonly in a separate engineering department or are a part of the respective manufacturing divisions, are a necessary and important part of the evolution of new things. This condition was given marked recognition by a very recent reorganization in the Department of Defense in which the two assistant secretaryships of Research and Development and Applications Engineering were first merged and then the resultant assistant secretaryship was abolished to become the Office of the Director of Research and Engineering.

In like manner, the powerful statistical tool which may be designated by the single term "quality control" (where quality control embraces applied statistics all the way from operations research to control of quality in the production process) should likewise be integrated into the spectrum of corporate technology. The quality-control function is essential to the corporation in its decision-making process and therefore should exist in the corporate staff, preferably under the Vice President for Research and Engineering. It is essential to research because of the design of experiments. It is essential to development as a part of the scientific method of hypothesis, experiment, and judgment of hypothesis. Without statistical analyses, judgment of hypotheses is

crude and weak. The quality-control function is essential to manufacturing for the economic control of quality in the process of manufacture, and its activities extend, of course, to marketing, customer complaints, and similar matters. Hence, research and development, quality control, and engineering are needed together to form a homogeneous structure of technology.

Although the determination of the numbers of people of each scientific or engineering discipline that one should have in each of the three areas of technology in the central laboratory and in each of the decentralized technical branches of the manufacturing divisions requires careful and exhaustive study, we can say in general that every decentralized manufacturing division should have the support (either within its own confines or from a similar manufacturing division) of a laboratory group consisting essentially of a development department (both for product development and process development), of a quality-control department (for such things as the design of quality-control procedures, design of experiments, and generation of specifications and standard inspection procedures), and of an engineering department (for the establishment of all things of an engineering nature, but not for their maintenance and upkeep). Small manufacturing divisions may have to depend upon the central research and engineering laboratories or related manufacturing divisions to supply the services of one or more of these departments, if smallness precludes their maintaining these capabilities.

Careful organization is important to each department within the technical branch of the manufacturing division. These departments should be capable of both vertical and lateral communication. For example, the engineering department should lend support to the development department, both in its product and in its process development. It also should lend similar support to the quality-control department. These are lateral functions. However, the engineering department must also lend vertical support to the production groups and receive advice from produc-

tion as a feedback. In a similar way, all departments of the technical branches of all of the manufacturing divisions should have direct lateral communication with their counterparts in the central laboratory without the necessity of going through higher echelons. Thus, there is a hierarchy in each general field; *e.g.*, development, engineering, and quality control, and problems beyond the scope or capability of any lower echelon in the field can be passed upward to a higher echelon which contains an economically appropriate number of persons of higher skill. One has a choice of adopting an integrated spectrum of technology of this sort or of accepting extravagant duplication of engineers in the manufacturing division and in the research and development echelon with concomitant clashes of jurisdiction, jealousies, and compartmentization of knowledge.

The Consequences of Organization by Spectrum and Disciplines

The advantages of having a continuous spectrum of technology in a corporation are rather evident. First, there is the saving in personnel. The much-discussed shortage of scientists and engineers is more apparent than real. There is some truth in the allegation that the shortage is aggravated by government. For example, a survey of the advertisements for scientists and engineers in the *New York Times* indicated that the advertisements were paid in large measure by government funds. However, the shortage is further emphasized by failure of management to use scientists and engineers in their highest capacity. In fact, recent studies made by some of our technical services indicate that on the average, technical men are used far less than halftime in their professional fields. If this costly type of professional service is utilized to best advantage, it means a marked monetary saving to the corporation.

In addition, transition troubles are obviated in large measure by the technical-branch type of organization. The gap from re-

search to development is effectively bridged. The still worse gap from development to production can become nonexistent. The orientation of the whole technical structure can be made consistent with the company aims and purposes, and technology will be geared to customer needs and markets so that technology will be generated and products will be developed, manufactured and perfected which are useful, for which there is a market, and which can be manufactured at a profit.

The effects on the individual are likewise favorable. Since the scientists and engineers become of greater value to the corporation, the corporation can well afford to pay them well. The scientist is relieved from doing tasks that are beneath him and is usefully occupied at his highest capacity at a maximum of time. His awareness of the world about him from the company viewpoint is greatly enhanced by improved channels of communication. A rewarding feeling of achievement is engendered, because he gets much more done and can see the material fruits for his labor and the concrete effects of his assistance to those located laterally and vertically to him. He lives more in a community of his fellows, both within his discipline and in kindred disciplines, and therefore develops wider interests. In short, his work, which after all is some 25 per cent of his life, is more rewarding and enjoyable.

This discussion has made quite a circuit to come back to the old engineering department; but, strictly speaking, it is not the old engineering department at all; it is an entirely bright, new, research and development-quality control-engineering branch, geared to management, geared to statistical techniques, geared to markets, and geared to corporation prosperity. In this new environment, we may consider ourselves not as scientists or engineers but as workers in the broad spectrum of technology.

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Sworn to and subscribed before me this 25th day of February, 1960.

[Seal]

(signed) Adelaide Rena Prenner
Notary Public
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